Management and monitoring of hyperthyroid cats: a survey of Australian veterinarians

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Abstract

Aim: This study sought to evaluate how Australian veterinarians approach management and monitoring of feline hyperthyroidism and compare these results to a similar survey recently performed in the United Kingdom (UK).

Method: An invitation to complete an online survey was sent to veterinarians in all states and territories of Australia. The survey comprised questions relating to management of hyperthyroidism, use of anti-thyroid drugs *v* radioiodine treatment *v* surgical thyroidectomy, in addition to demographic information for respondents.

Results: A total of 546 clinicians completed the survey. The most commonly preferred treatments for long-term management of feline hyperthyroidism were anti-thyroid medications (305/546; 56%) and radioiodine (210/546; 38%), with substantially more respondents selecting radioiodine when cost was removed as a consideration (425/546; 78%). However, most respondents had treated or referred few cases for radioiodine (median 2). Most veterinarians (500/546; 92%) used anti-thyroid medications either long-term or prior to definitive treatment of hyperthyroidism. For medical management, 45% (244/546) of veterinarians used twice daily carbimazole. Half of respondents (274/546) aimed to

maintain the total T4 concentration anywhere within the laboratory reference interval (RI) in hyperthyroid cats without chronic kidney disease. Blood pressure monitoring was uncommon. Surgical thyroidectomy was rarely performed.

Conclusions: Radioiodine was more frequently preferred by Australian veterinarians compared to those in the UK, likely associated with greater availability, reduced cost and shorter hospitalisation times in this jurisdiction, though anti-thyroid medications were the most frequently used treatment modality. Barriers remain to its utilisation, however, including perceived cost, misconceptions with regard to expected success rate and accessibility. Recent changes to recommendations on the management and monitoring of hyperthyroid cats do not appear to have been widely adopted by veterinarians at this time.

Keywords: Hyperthyroidism, cats, feline, survey, veterinarians, Australian, thyroid, methimazole, carbimazole, radioiodine

Introduction

Hyperthyroidism, first described in cats in 1979, is the most common feline endocrinopathy in most developed nations.[1,2] Recognised options for management of feline hyperthyroidism include administration of radioiodine, chronic daily dosing with anti-thyroid medication (orally or transdermally) and surgical thyroidectomy.[1] More recently, an iodine-restricted prescription diet has become available in certain countries.[3]

Radioiodine is regarded as the gold standard treatment, with advantages including: (i) potential for curative treatment, with approximately 94% of cats cured following a single treatment,[4] (ii) efficacy independent of location and type of hyperfunctional thyroid tissue, (iii) longer median survival compared to cats treated with anti-thyroid drugs, (iv) superior cost effectiveness for cats surviving beyond one year following diagnosis compared with anti-thyroid drugs and (v) safety, with minimal adverse effects and no requirement for general anaesthesia or even sedation in most instances.[4-8] However, restricted accessibility and requirement for hospitalisation can represent potential barriers to radioiodine use.[7,9] Curative success of thyroidectomy is dependent on the location of hyperfunctional thyroid tissue, which is important as ectopic hyperfunctional thyroid has been reported in 4 to 23% of hyperthyroid cats.[10,11] Complications can encompass iatrogenic hypoparathyroidism (6%

of patients in one study), recurrent laryngeal nerve damage and incomplete surgical resection.[12] Additional risk exists in anaesthetising older feline patients with co-morbidities such as chronic kidney disease (CKD) and thyrotoxic cardiomyopathy.[12] Overall 2% post-operative mortality has been reported.[12] Reported recurrence rates are 5 to 11% using various surgical techniques.[12,13] Anti-thyroid drugs can be an effective option but do not prevent progression of the underlying pathological process in the thyroid.[14,15] Therapeutic efficacy is also highly dependent on compliance with daily dosing.[14,16] Adverse effects have been reported in 18% of patients receiving methimazole including anorexia, vomiting, lethargy, and less commonly, self-induced facial excoriation, cytopenias, lymphadenomegaly hepatopathy and myasthenia gravis.[17,18] The prevalence of side effects using carbimazole is reported to be lower.[19,20]

A recent survey of general practice veterinarians in the United Kingdom (UK) evaluated their approaches to management and monitoring of feline hyperthyroidism.[21] In the UK, disadvantages of radioiodine have included limited availability and long waiting times, in addition to lengthy hospitalisation post-treatment due to radiation safety requirements (up to four to five weeks, until recently). In the UK survey, oral anti-thyroid medication was the most commonly preferred treatment option, however 59% of respondents agreed that

radioiodine was the gold standard for treatment of hyperthyroidism. [21] This highlights a discrepancy between the gold standard and the preferred treatment choice amongst veterinarians in the UK, raising the question of why such a discrepancy exists.

Radioiodine treatment in Australia differs in several ways to that in the UK. In particular, access to radioiodine treatment facilities is greater, with 20 radioiodine treatment facilities (https://madmimi.com/p/525d16 lists treatments facilities in Australia) across five of six Australian states (servicing a human population of 25 million people) and generally shorter post-treatment hospitalisation, typically five to seven days. As a result, we hypothesised that radioiodine may be more widely utilised amongst Australian veterinarians and more widely accepted as the gold standard treatment, compared to the UK.

This study aimed to evaluate how Australian veterinarians approach management of feline hyperthyroidism and compare these results to the UK survey.

Materials and methods

A survey of Australian general practitioners was modelled on the previous UK survey.[21] A list of veterinary practices that treat cats in the Australian Capital Territory (ACT), New

South Wales (NSW), Northern Territory (NT), Queensland, South Australia (SA), Tasmania, Victoria and Western Australia (WA) was compiled using several directories, including the Australian business telephone directory and any state registers of veterinary practices. An invitation to participate in the survey was sent to each veterinary practice (including branches) by e-mail or post (if an e-mail address was unavailable), including a request to forward survey information to all veterinarians in the practice. A total of 1,705 invitations were sent by email (ACT [26], NSW [527], NT [17], Queensland [368], SA [124], Tasmania [46], Victoria [401] and WA [196]) and 392 invitations by post (ACT [5], NSW [99], NT [1], Queensland [144], SA [23], Tasmania [8], Victoria [84] and WA [28]). Reminder e-mails were sent after one, three and four to five weeks. Reminders were not sent to postal recipients due to cost constraints. An iPad mini™ and three $100 textbook vouchers were offered as inducements for participation (winners were determined by ballot).

The questionnaire, hosted by the University of Bristol Online Survey Program, was based on that performed by Higgs *et al*,[21] with minor amendments to ensure appropriateness for Australian veterinarians. It comprised 32 questions divided into sections including: (i) general information on approach to management of hyperthyroidism, (ii) management of

hyperthyroidism with anti-thyroid drugs, (iii) radioiodine treatment, (iv) surgical treatment of hyperthyroidism and (v) respondent demographic information. At the time of the survey, the prescription diet (Hill's y/d®) had not been released in Australia and as such was not included in questions. We elected to use the same survey platform to minimise differences due to data acquisition.

Data were entered into a Microsoft Excel (Microsoft Office 15) spreadsheet and analysed using a statistical software package (Minitab version 17). Categorical and quantitative responses were analysed using descriptive statistics. Specific categorical responses were compared using χ^2 and odds ratio testing of cross-tabulated data. For all tests, *P* values <0.05 were considered significant.

Results

Demographics

There were a total of 546 respondents (Table 1), representing approximately 6% of registered veterinarians in Australia (9,782 veterinarians were registered in Australia in 2012).[22] Of these, 73% were female and 27% were male. Respondents had obtained veterinary training from the University of Sydney (n=147; 27%), University of Melbourne

(n=135; 25%), University of Queensland (n=122; 22%), Murdoch University (n=62; 11%), Charles Sturt University (n=10; 2%), University of Adelaide (n=5; 1%) and James Cook University (n=4; 1%), with remaining respondents having trained overseas (n=61; 11%). The median year of graduation was 2000 (range 1958 to 2014). The median number of veterinarians working in each veterinary practice was 3 (range 1 to 50). The median estimated percentage of the working day spent with cats was 30% (range 1 to 100%). In the practice where the respondent was working, 37% (n=202) had at least one person with post-graduate qualifications in small animal or feline medicine and 23% (n=123) in surgery.

Table 1. Number and percentages of survey respondents from Australian states and territories.

State or territory	Number of respondents (%)
Australian Capital Territory	18 (3)
New South Wales	156 (29)
Northern Territory	1 (0.2)
Queensland	93 (17)
South Australia	46 (8)
Tasmania	19 (3)
Victoria	170 (31)
Western Australia	43 (8)

Management of feline hyperthyroidism

In the previous six months, 72% of veterinarians (392/546) had diagnosed one to five cats with hyperthyroidism. Ninety-nine (18%) had diagnosed six to 10 cases, 28 (5%) had diagnosed 11 or more, while 27 (5%) had not diagnosed any. Preferred long-term treatment options were oral anti-thyroid medications (n=223; 41%), radioiodine (n=210; 38%), transdermal methimazole (n=82; 15%) and thyroidectomy (n=20; 4%). Veterinarians in WA were significantly less likely to prefer radioiodine (odds ratio [OR]=0.03; 95% confidence interval [CI] 0.00, 0.24; $P<0.001$) and significantly more likely to choose anti-thyroid medications (OR=7; 95% CI 3, 17; $P<0.001$). When cost was removed as a consideration, 425 veterinarians (78%) chose radioiodine as their preferred long-term treatment; this was significantly greater than the proportion who preferred radioiodine when cost was a consideration ($P<0.001$). Of remaining respondents, preferred treatments were oral anti-thyroid medication (n=61; 11%), transdermal methimazole (n=30; 5%) and thyroidectomy (n=25; 5%) when cost was not a factor.

Most veterinarians (406/546; 74%) indicated they did not have a practice policy for managing hyperthyroidism. Of those that did, 61 (44%) indicated their practice policy was long-term anti-thyroid medications, 45 (32%) was referral for radioiodine, 17 (12%) for in-house radioiodine and five (4%) for thyroidectomy. The importance of various factors to

veterinarians when formulating a long-term management plan is provided in Table 2. Data from eight respondents were excluded from analysis due to an initial computer error that affected data collection for this question alone.

	Degree of importance of each factor

Factor	Not at all important (%)	Not very important (%)	Not sure (%)	Important (%)	Very important (%)
Age of the cat	30 (5)	111 (20)	16 (3)	311 (57)	78 (14)
Co-morbid disease	0 (0)	3 (0.6)	4 (0.7)	184 (34)	355 (65)
Ease of drug administration	1 (0.2)	6 (1)	1 (0.2)	222 (41)	316 (58)
Owner compliance with medications	0 (0)	3 (0.6)	2 (0.4)	183 (34)	358 (66)
Cost of treatment	1 (0.2)	50 (9)	28 (5)	356 (65)	111 (20)
Cost of any required monitoring	5 (0.9)	83 (15)	38 (7)	364 (67)	56 (10)
Whether the pet is insured	118 (22)	240 (44)	92 (17)	76 (14)	20 (4)
Risk of drug side effects	7 (1)	82 (15)	44 (8)	345 (63)	68 (12)
Risk of surgical complications	26 (5)	58 (11)	69 (13)	258 (47)	135 (25)
Ease of referral for radioiodine	36 (7)	84 (15)	46 (8)	266 (49)	114 (21)
Indoor *v* outdoor cat	154 (28)	250 (46)	74 (14)	61 (11)	7 (1)

Table 2. Degree of importance of various factors when formulating a long-term plan for management of feline hyperthyroidism. Counts are provided, with percentage of total respondents in brackets (n=538).

Anti-thyroid medication

The majority of respondents (500/546; 92%) used anti-thyroid drugs as initial treatment for hyperthyroidism, either prior to curative treatment or for long-term term medical management, with oral carbimazole (Neomercazole®) used most commonly (244/546;

49%), followed by methimazole (Felimazole™, Dechra Veterinary Products) (109/546; 22%), transdermal methimazole (17/546; 14%), compounded oral methimazole or carbimazole (16/546; 3%) and carbimazole sustained-release tablets (Vidalta™, MSD Animal Health) (10/546; 2%). Remaining respondents (50/546; 10%) had no specific preference.

With regard to monitoring cats receiving anti-thyroid medications, 328/546 respondents (60%) designed their own monitoring protocol based on their perception of patient needs, 130 (24%) followed a practice policy and were comfortable that this was the best approach, 33 (6%) designed their own monitoring protocol based on owner preference and 31 (6%) designed their monitoring protocol based on manufacturer datasheet guidelines. Some respondents (19; 3.5%) indicated they follow a practice protocol but would prefer more frequent monitoring, while 5 (1%) indicated they did not believe any monitoring apart from physical examination was necessary. A summary of the frequency of monitoring various parameters in a hypothetical hyperthyroid patient is provided in Table 3. Of respondents selecting other in relation to this question, most indicated their frequency of assessment was made on a case-by-case basis.

Table 3. Frequency of assessment of physical examination and laboratory parameters when respondents were asked the following question: "You have recently diagnosed hyperthyroidism in a 12 year old cat and prescribed anti-thyroid tablets. Which of the following parameters would you routinely use to monitor the patient and how often?" Counts are provided, with percentage of total respondents in brackets (n=546).

Variable	Monitoring in early stages of treatment (%)		Frequency of assessment once stabilised (%)				Not assessed (%)
	In the first 3-4 weeks	In the 2nd-6th months	Every 3 months	Every 6 months	Yearly	Other	
Body weight (kg)	419 (78)	264 (49)	165 (31)	299 (56)	56 (10)	13 (2)	4 (0.7)
Serum TT4 concentration	446 (83)	246 (46)	75 (14)	356 (66)	69 (13)	23 (4)	2 (0.4)
Renal analytes (urea, creatinine, phosphate)	403 (75)	199 (37)	61 (11)	304 (57)	86 (16)	36 (7)	8 (1)
Liver enzymes activities (ALP, ALT)	299 (56)	157 (29)	40 (7)	226 (42)	119 (22)	26 (5)	40 (7)
PCV	258 (48)	119 (22)	27 (5)	191 (36)	104 (19)	23 (4)	89 (17)
Complete blood count	276 (51)	115 (21)	24 (4)	212 (39)	156 (29)	25 (5)	57 (11)
Full biochemistry profile	261 (49)	102 (19)	27 (5)	185 (34)	180 (33)	28 (5)	54 (10)
Blood pressure	263 (49)	131 (24)	66 (12)	195 (36)	41 (8)	43 (8)	147 (27)
In-house Urinalysis	321 (60)	141 (26)	63 (12)	219 (41)	100 (19)	42 (8)	52 (10)
Urinalysis externally (including UPCR)	54 (10)	28 (5)	11 (2)	41 (8)	38 (7)	95 (18)	278 (52)

ALT alanine aminotransferase; ALP alkaline phosphatase; PCV packed cell volume; TT4 total T4; UPCR urine protein to creatinine ratio

During therapy, 274/546 respondents (50%) aimed for total T4 concentration (TT4) to be anywhere in the laboratory reference interval (RI), 186 (34%) aimed for TT4 in the bottom half of the RI and 68 (12%) aimed for the upper half of the RI. One respondent (0.2%) aimed for TT4 to be just above the RI. In contrast, when there was pre-existing CKD, 244 respondents (45%) aimed for TT4 in the upper half of the RI and 84 respondents (15%) for TT4 to be just above the RI. These proportions were significantly different to the proportion of respondents aiming for TT4 in the upper half of the RI or just above the RI when pre-existing CKD was absent (OR 3; 95% CI 2, 5; $P<0.001$). Of remaining respondents, 98 (18%) indicated that the presence of CKD did not affect their target TT4 concentration, 65 (12%) aimed for TT4 concentration to be in the lower half of the RI and 46 (8%) only aimed to ensure the cat was not hypothyroid. Nine respondents (2%) did not monitor renal analytes in hyperthyroid cats.

Adverse reactions had been observed by 40% of veterinarians (217/546) in the previous 12 months (Table 4). Of veterinarians who had seen adverse reactions, 182/217 (84%) had not

reported them to the AVPMA or drug manufacturer. The most common ‘other’ adverse reactions identified were skin reactions to transdermal formulations and diarrhoea.

Table 4. Frequency and percentages of adverse reactions to anti-thyroid medications observed by respondents (n=217). Counts are provided, with percentage of total respondents in brackets.

Adverse reaction	Count (%)
Vomiting	143 (66)
Anorexia	98 (45)
Head and neck pruritus	57 (26)
Azotaemia	48 (22)
Elevated liver enzymes	45 (21)
Neutropenia	21 (10)
Leukopenia	16 (7)
Anaemia	12 (6)
Jaundice	7 (3)
Thrombocytopenia	5 (2)
Lymphadenomegaly	4 (2)
Other	8 (4)
Total	464

Surgical thyroidectomy

Only 119/546 veterinarians (22%) had performed one or more thyroidectomies on cat(s) with hyperthyroidism. Of these, 51 (43%) did not routinely submit resected thyroid tissue for histopathologic assessment, with 28/119 (24%) submitting 100% of samples, 26/119 (22%) submitting 1-20% of samples, and 14/119 (12%) submitting 21-99% of samples. Of samples submitted for histology, thyroid adenocarcinoma was diagnosed in no instance by

27 respondents (43%), 1-10% of cases by 20 respondents (32%) and 11-50% of cases by 10 respondents (16%). In cases undergoing bilateral thyroidectomy, recurrence of hyperthyroidism was noted in no cases by 39% of respondents (46/119), in 1-10% of cases by 23% of respondents (27/119) and in more than 11% of cases by 7% of respondents (8/119). Thirty-eight respondents (32%) had never been involved in bilateral thyroidectomy.

Most respondents believed that less than 10% (n=305; 56%) or 10-20% (n=173; 32%) of cats had ectopic thyroid tissue. Nuclear scintigraphy was uncommonly offered, with 51% (72/141) of veterinarians never offering it before surgery.

Radioiodine treatment

Eighty-two percent (447/546) of respondents either agreed or strongly agreed that radioiodine is the 'gold standard treatment' for hyperthyroidism, while 4.4% (n=24) either disagreed or strongly disagreed with this statement. The remainder (n=75; 14%) were unsure. With regard to the percentage of cases in which radioiodine was offered to clients, 214/546 (39%) respondents offered it in 100% of cases, 118 (22%) in 81-99% of cases, 66 (12%) in 51-80% of cases and 148 (27%) in less than 50% of cases. The median number of

cases respondents had either personally treated with or referred for radioiodine treatment was two (range 0 to 800). The closest radioiodine treatment centre was less than 50 km from 285 respondents (52%), 51 to 100 km away for 68 respondents (12%), from 100 to 300 km for 90 respondents (16%) and >301 km away for 82 respondents (15%). The remainder (21/546; 4%) did not know the location of their closest radioiodine treatment centre.

A summary of factors impacting respondents' likelihood of offering radioiodine are provided in Table 5, while the degree of concern caused to clients by various factors as assessed by the veterinarian are explained in Table 6. In relation to the likelihood of referring a hyperthyroid cat for radioiodine treatment, 399/546 respondents (73%) indicated they were either highly or quite likely to do this, while 88/546 respondents (16%) were either highly or quite unlikely to do this. The remainder were unsure (n=59; 11%).

Most veterinarians (323/546; 59%) considered that greater than 80% of cats were cured by standard doses of radioiodine, with 76 respondents (14%) selecting 61-80% of cats as being cured. The percentage of cats cured by standard doses of radioactive iodine was unknown by 119/546 respondents (22%).

Table 5. The effects of various factors on the likelihood of veterinarians offering radioiodine treatment to clients. Counts are provided, with percent of total respondents in brackets (n=546).

Factor	Definitely would not offer (%)	Quite unlikely to offer (%)	Not sure (%)	Quite likely to offer (%)	Definitely would offer (%)
Young cat e.g. 10 years or less	9 (2)	11 (2)	27 (5)	104 (19)	395 (72)
Old cat e.g. >15 years	32 (6)	133 (24)	67 (12)	158 (29)	156 (29)
Co-existing renal disease	83 (15)	205 (38)	107 (20)	97 (18)	54 (10)
Co-existing/secondary heart disease	44 (8)	141 (26)	127 (23)	131 (24)	103 (19)
Poor owner and/or cat compliance for drug administration	10 (2)	26 (5)	21 (4)	154 (28)	335 (61)
Good owner and/or cat compliance for drug administration	11 (2)	74 (14)	40 (7)	176 (32)	245 (45)
Poor response to drug therapy	8 (1)	28 (5)	48 (9)	160 (29)	302 (55)
Good response to drug therapy	16 (3)	137 (25)	56 (10)	134 (25)	203 (37)
Recurrence of disease after thyroidectomy	11 (2)	18 (3)	108 (20)	130 (24)	279 (51)
Cat is insured	7 (1)	4 (0.7)	52 (10)	147 (27)	336 (62)
Cat is not insured	9 (2)	44 (8)	78 (14)	148 (27)	267 (49)
Suspected ectopic thyroid tissue	8 (1)	13 (2)	114 (21)	143 (26)	268 (49)
<2 hours travel to nearest radioiodine centre	8 (1)	11 (2)	52 (10)	160 (29)	315 (58)
>2 hours travel to nearest radioiodine centre	17 (3)	97 (18)	82 (15)	143 (26)	207 (38)
Long waiting list (>3 months)	16 (3)	96 (18)	84 (15)	153 (28)	197 (36)
No waiting list for radioiodine	9 (2)	7 (1)	74 (14)	158 (29)	298 (55)

Table 6. The degree of concern caused to clients by various factors relating to radioiodine treatment, as assessed by the veterinarian. Counts are provided, with

Factor	No concern (%)	Little concern (%)	Great concern (%)
Cost of treatment	7 (1)	92 (17)	446 (82)
Distance of travel to the radioiodine treatment facility	68 (13)	212 (39)	264 (49)
Risk of radiation exposure	70 (13)	344 (63)	128 (24)
Potential for development of side effects of the treatment	39 (7)	315 (58)	189 (35)
Potential for development of co-morbid disease during	44 (8)	310 (57)	187 (35)

percent of total respondents in brackets (n=546).

isolation			
Possibility of the cat being unhappy away from home	28 (5)	179 (33)	338 (62)
Possibility of development of anorexia away from home	34 (6)	272 (50)	235 (43)
Possibility of the owner or other family members missing the cat	63 (12)	269 (50)	211 (39)
Possibility other pets may miss the cat	148 (27)	311 (58)	81 (15)

Laboratory testing of serum TT4 concentrations

Most veterinarians (352/546; 64%) were aware of the different laboratory methods available for monitoring TT4. An external laboratory was used for measuring TT4 concentration by 449/546 respondents (82%), with remaining respondents using in-house testing. Half of respondents (225/449; 50%) used an external laboratory where TT4 is measured by enzyme immunoassay.

Discussion

Feline hyperthyroidism is commonly diagnosed by Australian veterinarians. Radioiodine was a preferred long-term treatment option by more than a third (38%) of respondents, which increased to 78% when cost was removed as a consideration. However, anti-thyroid

medications were the most frequently used treatment modality and twice daily carbimazole preferred by 49% of surveyed veterinarians. Surgical thyroidectomy was rarely performed.

Greater preference for radioiodine amongst Australian veterinarians contrasts with the UK survey. In that survey, only 6% of respondents preferred radioiodine treatment for long-term management, rising to 41% when cost was not considered.[21] Factors including reduced hospitalisation times compared to those historically in the UK and more widespread availability of treatment facilities in Australia may have led to a more positive attitude to radioiodine. In our survey, the impact of accessibility was highlighted by significantly reduced preference for this treatment modality amongst WA veterinarians, where no such facilities currently exist.

In spite of widespread preference for radioiodine treatment, Australian veterinarians treated or referred very few cases for radioiodine treatment (median 2). This suggests that barriers to radioiodine utilisation persist in Australia. Indeed, 22% of veterinarians were unaware of the success rates of radioiodine treatment and an additional 19% underestimated the percentage of cats cured by standard doses of radioiodine. As a result, veterinarians may offer referral for radioiodine, but may not do so in a sufficiently compelling manner for

clients to opt for this treatment. Similarly to Higgs and colleagues' survey,[21] compliance with treatment, ease of drug administration, co-morbidities, treatment expense and monitoring emerged as important factors when developing long-term plans for hyperthyroid cats. Importantly, 82% of veterinarians reported they perceived radioiodine treatment cost was of great concern to clients. This contrasts with a survey of UK owners where cost had low impacts on the selected treatment, although that may be due to greater adoption of pet insurance in this jurisdiction.[9] Veterinarians may also overemphasise the role of cost in owner decision-making. While there is some variation in treatment expenses for hyperthyroidism, typically the cost of curative treatment approximates one year of daily anti-thyroid medication and monitoring. Therefore, on a cost basis, curative treatment should be strongly considered where a cat is expected to live more than 12 months post-diagnosis.[14,23]

Despite the advantages of radioiodine, anti-thyroid therapy was used by more than 90% of veterinarians in our survey, either for long-term management or prior to curative treatment. Problematically, anti-thyroid drugs fail to treat the underlying pathologic process. As a result, there is propensity for the primary process to progress, with eventual refractoriness to medical management and sometimes malignant transformation. Indeed, the prevalence of

thyroid carcinoma is reported to increase from less than 5% to 19% in cats managed with anti-thyroid medication for more than four years.[14,15] Cats treated with methimazole have shorter survival times than those treated with radioiodine; client compliance with drug administration, poor titration of therapy and drug toxicoses have been hypothesised to account for this observation.[8] While the reversibility of anti-thyroid medication allows assessment of the effects of restoring euthyroidism on renal function,[14] the importance of trialling this before definitive treatment is now being challenged, particularly when pre-existing azotaemia is absent. A recent study showed that hypothyroid cats that become azotaemic following treatment have shorter survival times.[24] Emphasis should therefore be placed on carefully monitoring thyroid status after definitive therapy to avoid hypothyroidism by pre-emptive replacement therapy with thyroxine, where necessary.

The most commonly used anti-thyroid medication was twice daily carbimazole, rather than licensed methimazole (Felimazole™) or sustained-release once daily carbimazole (Vidalta™). This likely reflects familiarity as the latter two medications have only recently become available in Australia. However, it serves to emphasise the need for veterinarians to remain abreast of new drugs, particularly those that have potential to improve compliance by reducing administration frequency. Transdermal methimazole was often used by

respondents to our survey. It is thought to improve client compliance,[14,25] but a study evaluating long-term transdermal methimazole use found 17% of owners admitted not treating their cat regularly, suggesting compliance may still be suboptimal.[26] Adverse reactions of anti-thyroid medications were consistent with previous reports.[14] Interestingly, few veterinarians had reported adverse reactions to the manufacturer or relevant authority, suggesting significant under-reporting exists, similar to the UK study.[21]

Surgical thyroidectomy had been performed by approximately one-fifth of respondents in our survey, but only 4% of veterinarians selected thyroidectomy as their preferred treatment, compared to 28% in the UK.[21] Barriers to performing thyroidectomy in general practice, including in Australia, may include concern regarding anaesthetic risks associated with co-morbid conditions such as CKD or cardiomyopathy, limited access to nuclear scintigraphy to assess the location of hyperfunctional thyroid tissue, limited experience performing the surgery and absence of adequate post-operative monitoring to manage complications such as hypocalcaemia. The majority of veterinarians were aware that ectopic hyperfunctional thyroid tissue could be present in 4 to 23% of hyperthyroid cats.[10,11]

Evaluation of serum TT4 is essential for diagnosis and monitoring of hyperthyroidism. Methods for measuring TT4 include radioimmunoassay (RIA), chemiluminescent enzyme immunoassays (CEIA) and enzyme immunoassays (EIA; also available as in-house assays), with all but RIA being relatively inexpensive and widely available.[27] While CEIA provides similar results to the gold standard RIA, EIA has higher rates of false positive and false negative results and tends to underestimate TT4, leading to discordant results in 24% of cases.[27] In Australia, the major veterinary laboratories use different techniques and therefore results cannot be compared between laboratories. Veterinarians must be aware of test methodologies and their varying precision at diagnosing and monitoring hyperthyroid cats using TT4. The in-house EIA has also been evaluated with conflicting reports on its usefulness for TT4 measurement, but one study suggested its accuracy to be lower than other methodologies.[27-29] With in-house EIAs used by 18% of veterinarians in our survey, and widespread use of a commercial laboratory that uses EIA, many veterinarians may be unaware of the potential for spurious and misleading results. We advise utilising laboratories that use the CEIA methodology, as has been recommended by Peterson.[27] Although generally accepted that the treatment goal when using anti-thyroid medications is for TT4 concentration to be within the lower half of the RI,[14] 50% of respondents aimed for TT4 to be anywhere within the RI and 12% aimed for it to be in the upper half of the RI (in

the absence of CKD). This suggests that many cats may be inadequately treated and consequently may continue to experience the adverse pathophysiological effects of hyperthyroidism. While there was a statistically significant increase in the number of respondents aiming for TT4 to be in the upper half or above the reference interval when CKD was present, many veterinarians do not appear to be aware of current advice regarding management of hyperthyroid cats with concurrent renal azotaemia, which is for TT4 to be maintained in the lower half of the reference interval, but to avoid hypothyroidism; only 8% aimed to ensure that the patient did not become hypothyroid.

A recent review of best practice for monitoring cats managed with anti-thyroid medication emphasised regular history taking, serial examinations, bodyweight and body condition score estimations, TT4 concentrations measured by the same laboratory, renal analytes and systolic blood pressure.[14] In our survey, monitoring in the initial few weeks of therapy was generally adequate. However, during maintenance therapy, blood pressure monitoring was significantly underutilised, with less than half of clinicians complying with monitoring recommendations.[14] Similar observations were made in the survey by Higgs *et al*.[21] Regular assessment of hyperthyroid cats after treatment is important to prevent devastating hypertensive sequelae such as retinal or intracranial haemorrhage as well as detrimental

effects on renal function. Hypertension is present in 14 to 23% of hyperthyroid cats at diagnosis, though has been reported in up to 87% of cats in one study, and importantly, 23% of initially normotensive cats develop hypertension following restoration of euthyroidism.[30-32] Hypertension has been correlated with reduced survival times in a retrospective study of cats treated primarily with anti-thyroid medications and/or thyroidectomy.[33]

Practice policies for management of feline hyperthyroidism were reported by approximately one-quarter of veterinarians in our survey. The most common practice protocol was for long-term management with anti-thyroid medications. Although there may be valid reasons for this, it underscores the importance of continuing to raise awareness of best practice for managing hyperthyroidism and consideration of tailoring long-term treatment plans to the individual patient and owner. For non-azotaemic cats expected to live more than 12 months after diagnosis, practice policies for long-term anti-thyroid medications may be promoting suboptimal treatment associated with shorter survival times, likely reduced quality of life and increased risk of development of thyroid carcinomas.[8,15]

The current study suffers from some limitations, similar to those reported by Higgs and collaborators.[21] Inherent limitations of surveys include difficulty with recall, leading to inaccurate responses and bias in responding to the questions by predicting the desired response rather than reflecting the usual practices of the respondent.[34] The distribution of veterinarians in the Australian states and territories was largely similar to the percentages of respondents from these locations in our survey, suggesting the survey may be representative of veterinarians across Australia.[35] In addition to this, the survey was conducted prior to the release of the iodine-restricted prescription diet in Australia and as a result, it is not possible at this time to determine how it will influence treatment decisions for hyperthyroid cats.

Conclusions

Despite radioiodine treatment being more commonly preferred amongst Australian veterinarians compared to those in the UK, practical barriers persist that limit its utilisation, particularly high initial cost, misconceptions regarding efficacy and availability of referral centres in some regions of Australia. When discussing treatment options with owners, veterinarians should emphasise the significant advantages of radioiodine treatment and its overall cost effectiveness in cats expected to live greater than 12 months post-diagnosis.

Long-term anti-thyroid medication was the most frequently preferred treatment modality for hyperthyroid cats in our survey. Anti-thyroid medications were also commonly used on a trial basis before definitive management. Current evidence suggests that this may be unnecessary in cats that are non-azotaemic prior to radioiodine treatment, though should still be considered prior to thyroidectomy so anaesthesia is performed in a stable patient. Monitoring practices of veterinarians in our survey were similar to those in the UK survey and may be improved by enhanced emphasis on regular blood pressure determination and appropriately targeting TT4 concentrations while using carbimazole or methimazole in both non-azotaemic and azotaemic hyperthyroid cats. Practice policies for management of feline hyperthyroidism, particularly where they advocate long-term medical management, should be discouraged in favour of tailoring management of hyperthyroidism based on patient and client factors with reference to current literature.

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Conflicts of interest

The authors do not have any potential conflicts of interest to declare.

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